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# CHILDREN'S TELEVISION WORKSHOP

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

**BY HAND DELIVERY**

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

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**RE: Children's Television Programming**
**MM Docket No. 93-48**

Dear Mr. Caton:

Relying on a glib, unresearched opinion piece in *The Weekly Standard* entitled "The Dirty Little Secret of Educational TV," some have recently publicly questioned a conclusion we had thought no longer assailable on any principled basis: that television can significantly enhance children's learning. Although the proponents of this challenge give lip service to the Commission's mandate to enforce the programming requirements of the Children's Television Act, they argue that children gain very little in real educational benefits from television.

In point of fact, the foundation on which the CTA rests is Congress' explicit recognition, based on well-grounded academic research and expert testimony, not only of television's general ability to teach effectively, but also of the educational effectiveness of particular programs designed to teach specific skills, including such Children's Television Workshop programs as *Sesame Street*, *The Electric Company*, *3-2-1 CONTACT*, and *Square One TV*. See S. Rep. No. 227, 101st Cong., 1st Sess. 5-7 (1989).

Throughout its 27-year history, CTW has heavily utilized both formative and summative research to develop, evaluate and refine the educational effectiveness of its program offerings. Attached to its October 16, 1995 Comments in the present proceeding were Wright and Huston's May, 1995 study on the positive causal role of young disadvantaged children's viewing of *Sesame Street* and other educational programs in their development of school readiness. Also supplied with CTW's Comments were a June 23, 1994 report by Westat, Inc.

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finding significant differences in emerging literacy between preschool viewers and non-viewers of *Sesame Street*, and an October, 1995 study demonstrating that CTW's animated program *Cro* (an educational program about technology) was as appealing as *The Flintstones*.

The following additional research materials demonstrating that children benefit in important ways from viewing programming designed to meet their educational and informational needs are attached:

- *A Study of the Effects of CRO*, with separate *Executive Summary* (Learning Research and Development Center, University of Pittsburgh, 1995). This study found that viewing *Cro* increased children's interest in and understanding of the technology featured in the series.

- *Learning from GHOSTWRITER: Strategies and Outcomes* (CTW, 1994), and *GHOSTWRITER and Youth-Serving Organizations* (CTW, 1994). These reports demonstrated that *Ghostwriter*, a multimedia literacy project centered on the weekly television series, motivated 6- to 11-year-old children to value and enjoy reading and writing, and taught important social and moral lessons. Use of *Ghostwriter* magazine and other ancillary materials by Boys and Girls Clubs, Girl Scouts, YMCAs and other youth-serving organizations, in conjunction with home viewing of the series, created synergistic and multiplicative learning effects.

- *Television and Children's Problem-Solving Behavior: A Synopsis of an Evaluation of the Effects of Square One TV* (Journal of Mathematical Behavior 9, 161-174, 1990). Viewing of *Square One TV* increased nonroutine mathematical problem-solving performance.

- *Sesame Street Research Bibliography: Selected citations relating to Sesame Street 1969-1989* (CTW, 1990). This publication lists hundreds of research studies of the impact of *Sesame Street* on reading, mathematical and thinking skills, language acquisition, school readiness, social and emotional development, attention, comprehension and memory, and on children with disabilities.

CTW respectfully suggests that after more than twenty-five years of studies demonstrating that *Sesame Street* and other educational programs can and do teach children, it is time for the Commission to address how it can promote such programming, not whether doing so will have any substantiated positive effect.

Respectfully submitted,

Gary E. Knell
BKG

Gary E. Knell
Senior Vice President for Corporate Affairs

Attachments

cc (without att.) (by hand):
The Honorable Reed E. Hundt
The Honorable James H. Quello
The Honorable Andrew C. Barrett
The Honorable Rachelle B. Chong
The Honorable Susan Ness

JOURNAL OF MATHEMATICAL BEHAVIOR 9, 161–174 (1990)

# Television and Children's Problem-Solving Behavior: A Synopsis of an Evaluation of the Effects of *Square One TV*

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*Children's Television Workshop*

Children's Television Workshop has conducted a study of the effects of programs from the first two seasons of a television series about mathematics, entitled *Square One TV*, aimed at an at-home audience of 8- to 12-year-old children. One of the goals of the series is to encourage the use and application of problem-solving processes. The study was organized in a pre/post experimental/control design, with a treatment consisting of watching 30 half-hour programs of *Square One TV*. Subjects ($N = 48$) were individually interviewed and videotaped using a set of nonroutine mathematical problems, and their performance was measured by two scores: one involving the number and variety of problem-solving actions and heuristics used, the other involving the mathematical completeness and sophistication of their solutions. Gains from pretest to posttest in both scores were significant for the experimental group, and significantly greater for the experimental group than the control group, indicating that persistent viewing of *Square One TV* can increase problem-solving performance in its target audience. Implications for recent widespread efforts to improve mathematics education in the U.S. are discussed.

*Square One TV* is a television series about mathematics, produced by Children's Television Workshop (CTW). It is aimed at an audience of 8- to 12-year-old viewers, primarily watching at home (although some stations carry the program

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The production of *Square One TV* and the research summarized here have been supported by the National Science Foundation, the Corporation for Public Broadcasting, the Carnegie Corporation, and the U.S. Education Department. First season production was also supported by the Andrew W. Mellon Foundation and by IBM. The authors gratefully acknowledge the contributions of Robert B. Davis; Elizabeth K. Stage; Stephen S. Willoughby; Terence Tivnan; Keith W. Mielke; Bettina Peel; David D. Connell, Joel Schneider, and the *Square One TV* staff; and our colleagues in this study, Dorothy T. Bennett, Samara V. Solan, Elizabeth Debold, M. Audrey Korsgaard, Barbara Miller, and Karen McClafferty. We are also grateful to the Department of Elementary Curriculum of the Corpus Christi Independent School District, as well as the principals, staff, and students of the participating schools, without whom this study would have been impossible.

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during school hours). The program is 30 minutes long and is generally broadcast Mondays through Fridays on public television stations. The first two production seasons resulted in a total of 115 programs. Season III, which premiered in January, 1990, consists of 40 new programs. Season IV production is now under way.

*Square One TV* has three goals. Goal I is to promote positive attitudes toward, and enthusiasm for, mathematics; Goal II is to encourage the use and application of problem-solving processes; and Goal III is to present sound mathematical content in an interesting, accessible and meaningful manner. Each of these goals is refined into a range of subgoals; the complete breakdown is fully explicated in the goals statement (see Appendix 1).

Each segment of every program in Seasons I, II, and III has been carefully analyzed to determine which subgoals it incorporates; as a result, one has detailed knowledge of how the goals are reflected in the programs. A natural question that arises is the degree to which regular viewers of *Square One TV* are affected by the material that is directed toward the goals.

An earlier CTW study (Peel, Rockwell, Esty, & Gonzer, 1987) found that children in the target age group can recall and comprehend mathematical content presented in a sample of Season I segments, and that in many cases they can extend that information to different, but related, problem situations. The study also probed for children's interpretation of the characters' feelings or attitudes toward the mathematical situations in which they found themselves. However, that study was not designed to incorporate a thorough investigation of children's own views of mathematics or their abilities to apply the problem-solving processes and heuristics illustrated in *Square One TV* to novel problem situations.

The current study was a natural outgrowth of the earlier work. Its purpose was to address Goals I and II directly: It examined in great detail the changes that might occur in children's attitudes toward mathematics and in their inclination to use problem-solving techniques as a result of sustained viewing of *Square One TV*.

With regard to Goal I of the series, the study is designed to explore children's attitudes toward mathematics. Here, we have conceived of "attitude" as pertaining to issues of motivation, enjoyment, perceptions of usefulness and importance, and children's conceptions of what mathematics is, that is, their "construct" of mathematics. The study attempts, first, to provide a detailed description of each of these aspects of children's attitudes toward mathematics, and, second, to examine the degree to which *Square One TV* can influence those attitudes. With regard to Goal II, the study examines the impact of *Square One TV* on children's problem-solving actions (particularly problem treatment and problem follow-up) and the extent to which they use a variety of heuristics (e.g., constructing tables or graphs, looking for patterns, or working backwards) in problem solving. Furthermore, the study assesses the impact of the series on the mathematical completeness and sophistication of children's solutions to nonroutine problems.

This synopsis summarizes *one part* of the study—its investigation of children's problem solving. The data from another part of the study, concerned with attitudes, are currently being analyzed.

## METHOD

### Subjects

The subjects for the study were fifth graders in four public elementary schools in Corpus Christi, TX. (This site was chosen because it is one of the few cities in the country in which *Square One TV* had not been part of the regular public television broadcast schedule prior to completion of data collection. Also, none of the participating schools had shown *Square One TV* as part of classroom instruction.)

All the schools used the same standard mathematics textbook and curriculum. Moreover, the four schools were matched as pairs on the basis of standardized achievement test scores, racial/ethnic composition, and student socioeconomic status (SES). One pair of schools served mostly lower-SES children, and the other two schools were largely middle SES. One school in each pair was randomly designated as an experimental (viewing) school, and the other was designated as a control (nonviewing) school.

A total of 48 children, 12 from each school, participated in the part of the experiment described here. They were drawn from all of the regular fifth-grade classrooms in the four schools. Children within matching schools were matched as pairs on gender, race/ethnicity, achievement test scores, and eligibility for free lunch (used as a further indicator of SES).

### Treatment

All fifth graders in the two experimental schools were exposed to programs from Seasons I and II of *Square One TV*. They watched one program each weekday for 6 weeks, a total of 30 half-hour programs. The viewing took place during school hours, but not during regularly scheduled mathematics classes. The teachers in the viewing schools did not alter their usual mathematics instruction in any way. They did not use *Square One TV* as part of their teaching, they did not comment on it, and they did not make any connection between the program and mathematics. Thus, the experimental exposure to the series consisted of sustained unaided viewing in a group setting.

The two control schools did not see *Square One TV* at all; their schedule did not change from what it usually was.

### Instruments

A variety of instruments was used, aimed at assessing problem-solving performance and attitudes. The problem-solving instruments, called Problem-Solving Activities (PSAs), are a range of mathematically rich, nonroutine, problem situations. Each PSA allows children to demonstrate the problem-solving actions oi Goal II and to reach solutions through a variety of approaches. The PSAs all involve a manipulative component, and they are substantively different from problems traditionally encountered in elementary school mathematics.

The PSAs comprise three levels of complexity. Level C problems are the most complex (see Appendix 2 for a brief description of one of these), followed by Level B (moderately complex), and Level A (the least complex).

At both the pretest and the posttest, three PSAs were administered to individual children over two 55-minute sessions on 2 successive days. (An attitude interview was also conducted during the second day.) The procedure for administering each PSA was as follows. The researcher described a problem situation to the child, using a written interview protocol. The child was given time to work on the problem alone. Following this activity, the researcher used the protocol along with a series of standard probe questions to get at what the child was thinking during the work session. Special emphasis was placed upon having the child describe and assess the choices he or she made during the problem-solving process. Table 1 summarizes the schedule used to administer the PSAs.

There were two versions of each level of PSA—A and A′, B and B′, C and C′. Eight months of pilot testing determined that it is possible to use two variants of each PSA while maintaining the same level of difficulty from the pretest to the posttest. In fact, *t* tests on pretest data from the main study revealed no significant differences in children's performance within each pair of problems, indicating that difficulty did not vary within pairs of problems. (Henceforth the pair A and A′, for example, will be referred to as A*.)

One set of PSAs (either C, B, A or C′, B′, A′) was administered to each child at the pretest, and the other at the posttest. Within each set, the most complex problem (C or C′) was used first and the least complex last. Half the children at each school used one set for the pretest and the other set for the posttest; the order was reversed for the other children.

**TABLE 1**
**Schedule of the Study**

| | Groups | |
|---|---|---|
| | Experimental (Viewing) | Control (Nonviewing) |
| Pretest | Day 1: Two PSAs<br>Day 2: One PSA | Day 1: Two PSAs<br>Day 2: One PSA |
| Treatment | View 30 programs of *Square One TV* | No change from normal schedule |
| Posttest | Day 1: Two PSAs<br>Day 2: One PSA | Day 1: Two PSAs<br>Day 2: One PSA |

To prevent experimenter bias, the interviewers were not informed of the viewing/nonviewing status of the children. As an additional safeguard, interviewers had no contact with any classroom teachers. Furthermore, special care was taken to insure that the children made no connection between the interviewing and *Square One TV*.

### Coding Schema

The coding system used to quantify the children's performance on these PSAs analyzed processes employed and paths explored as well as how close the child came to reaching a correct solution. The coding system was based on the child's verbal reports and overt behaviors as sources of evidence, rather than on coders' inferences. Furthermore, the system was directly tied to the statement of *Square One TV*'s Goal II (see Appendix 1): The behaviors of interest were the problem-solving actions and heuristics described in the subgoals of Goal II.[1] Coders examined the videotapes and verbatim transcripts of the interviews, guided by detailed coding manuals that provided dozens of explicit examples of how the children's behaviors should be coded. Like the interviewers, the coders were not informed of the viewing/nonviewing status of the children.

## OVERVIEW OF RESULTS

For each of the three PSAs, each child was scored on two measures: (1) the number and variety of problem-solving actions and heuristics used (the *P*-score[2]), and (2) the mathematical completeness and sophistication of the solution reached (the *M*-score). These two scores are conceptually independent in the sense that a child's use of a large number of problem-solving actions or heuristics would not necessarily lead to a sophisticated or complete solution; and, conversely, a sophisticated and complete solution might be obtained despite a child's use of a very limited problem-solving repertoire.

The principal results of the study can be summarized as follows:[3]

- From pretest to posttest, children in the viewing group made *significantly greater P-score gains* on each of the three PSAs than the nonviewers did. (Two-way ANOVAs showed interactions of pre/post with viewer/nonviewer to be significant at the $p < .001$ level for PSAs A*, B*, and C*.) The viewers' pretest to posttest gains were significant ($p < .001$ for PSA A* and

[1]This correspondence between program goals and assessment is an example of "alignment," as described in the National Council of Teachers of Mathematics' *Standards* (1989).

[2]The *P*-score incorporates 17 problem-solving actions and heuristics that are derived from the subgoals of Goals IIB, IIC, and IID.

[3]Note that we have set our alpha level for significance at $p < .05$. Any results reported here as significant have reached at least that level of significance.

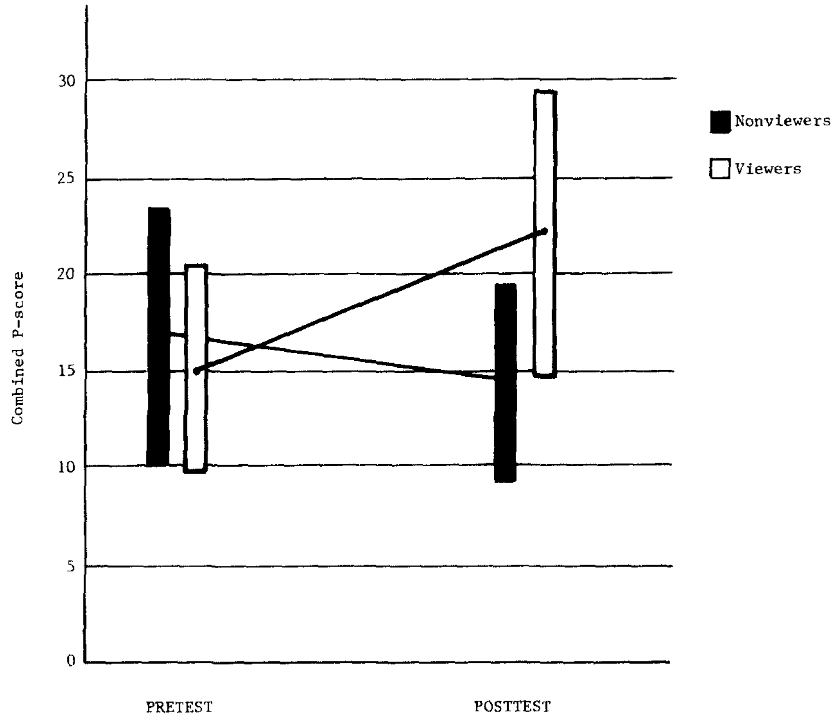


**Figure 1.** Mean P-scores (All PSAs Combined) for Viewers and Nonviewers on Pre- and Posttest, with 1 *SD* Above and Below the Means

C*; $p < .01$ for PSA B*); the nonviewers did not make significant gains. Furthermore, at the posttest, there was a significant *P*-score difference between the viewers and nonviewers in each PSA ($p < .001$ in each case). Figure 1 shows the combined[4] mean *P*-scores of the two groups at the pretest and posttest, with an interval of 1 *SD* above and below each mean.

It is clear from Figure 1 that there is substantial overlap between the viewers' and nonviewers' *P*-scores at the pretest. At the posttest, however, the viewers' *P*-scores increased significantly, whereas the nonviewers' did not.[5] At the posttest, then, there was much less overlap between the two groups.

- From pretest to posttest, children in the viewing group made ***significantly greater M-score gains*** than nonviewers on two of the three PSAs. (Two-way

[4]The pairwise correlations among P-scores for PSAs A*, B*, and C* were all positive and significant at the $p < .01$ level, or even more significant. The combining of *P*-scores was done via principal components analysis.

[5]The decline in the nonviewers' mean combined *P*-score is marginally significant, $p < .10$. The nonviewers' *P*-scores declined significantly in PSAs A* and B*, $p < .01$, but not in C*.

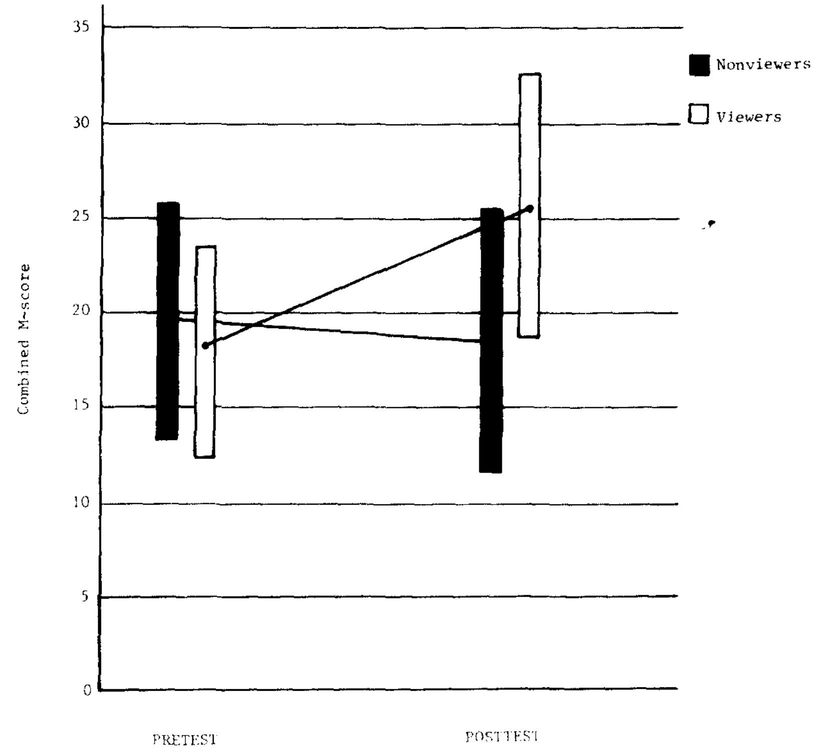


**Figure 2.** Mean M-scores (all PSAs combined) for viewers and nonviewers on pre- and posttest, with 1 *SD* above and below the means.

ANOVAs showed interactions of pre/post with viewer/nonviewer on PSA A*, $p < .01$, and PSA C*, $p < .001$.) From pretest to posttest, the viewers' *M*-scores increased significantly on PSAs A* and C*, $p < .001$. Furthermore, the difference between the two groups at the posttest was significant in PSA C*, $p < .001$, and marginal in PSA*, $p < .10$.[6]

Figure 2 shows the mean total[7] *M*-scores of the two groups at the pretest and the posttest, with an interval of 1 *SD* above and below each mean.

The same pattern observed for *P*-scores is apparent here: At the pretest there is substantial overlap between the two groups. However, at the posttest

[6]*M*-score changes in PSA B* were not significant for either group. Something akin to a ceiling effect appeared to be operating in the sophistication and completeness of children's solutions to this problem at both pretest and posttest. Thus, there was little change from pretest to posttest.

[7]For summary purposes only, the *M*-scores from the three PSAs were combined simply by adding them. The correlations among the *M*-scores for PSAs A*, B*, and C* were not all significant, so any combination of *M*-scores across the three PSAs should be interpreted with caution.

the viewing group's $M$-scores were significantly higher, resulting in much less overlap. The nonviewers's $M$-scores did not change significantly from pretest to posttest on any of the PSAs.

- Even though the $P$- and $M$-scores are conceptually independent, in this sample they were significantly correlated, $r = .52$, $p < .001$; higher $P$-scores tended to be associated with higher $M$-scores. For reasons detailed in the full report, we posit that there is a *causal* relationship between the $P$-scores and $M$-scores: An increase in $P$-score (a greater tendency to use problem-solving actions and heuristics) *leads to* an increase in $M$-score (mathematical sophistication and completeness of solution).
- There were no significant gender differences in children's $M$-scores at either the pretest or the posttest. Furthermore, the changes in children's $M$-score performance from pretest to posttest did not interact significantly with their gender.

  Similarly, gender did not have a significant main effect on children's $P$-scores. Both boys and girls who watched *Square One TV* improved significantly, $p < .01$, from pretest to posttest, and there was no difference between boys and girls in the viewing group at either the pretest or the posttest.[8] Thus, it appears that *Square One TV* had a similar effect on the boys and girls in the viewing group.
- Middle-SES children received higher $P$-scores than did low-SES children, $p < .01$, and higher $M$-scores on two of the three PSAs ($p < .01$ for PSA A*; $p < .05$ for PSA C*). But, as in the case of gender, the changes in children's $P$-scores and $M$-scores did not interact significantly with SES, indicating that *Square One TV* exerted a similar effect on the low- and middle-SES children in this sample.

  In this study, minority (i.e., African-American and Latino) children were largely of lower SES, and nonminority (i.e., Anglo) children were of middle SES. Thus, a pattern similar to the one found for SES emerged when the data were analyzed by ethnicity. That is, nonminority children received higher $P$-scores than minority children, $p < .05$, and marginally higher M-scores in PSA C*, $p < .10$, but there was no significant interaction between SES and change in either $P$-scores or $M$-scores. This indicates that *Square One TV* affected minority and nonminority children similarly.
- Ten months before the study started, school district personnel administered an annual standardized mathematics achievement test to all fifth graders in the district. The children's scores on this achievement test were not significantly correlated with their $P$-scores or $M$-scores on any of the PSAs. (The correlations between $P$-scores and standardized test scores range from $-.18$ to $.11$;

[8]There was, however, a marginal, three-way interaction among gender, condition, and pretest/posttest, $p < .10$; this was attributable to a drop, $p < .05$, from pretest to posttest in the *nonviewing* girls' $P$-scores.

the correlations between $M$-scores and standardized test scores range from $-.07$ to $.02$.) In addition, viewers' achievement test scores were not significantly correlated with their changes in either $P$-scores or $M$-scores on any of the PSAs. (The correlations range from $-.26$ to $.26$ for $P$-scores and from $-.11$ to $.06$ for $M$-scores.)

A set of more detailed analyses was carried out to explain the sources of the viewers' significantly increased $P$-scores. Some of the results, briefly, are these:

- An average of 42% of the problem-solving actions and heuristics that the viewers used in the posttest was *new*, that is, actions that they had not used in the pretest. This proportion for viewers was significantly larger than the average of 25% observed for nonviewers ($p < .005$ for PSA A* and C*; $p < .10$ for PSA B*).
- For each of the PSAs, we tallied the number of problem-solving actions and heuristics for which there was an increased use from pretest to posttest. Averaged over the three PSAs, viewers increased in their use of 11.7 of the 17 actions and heuristics, whereas nonviewers increased in only 4.0 of the 17.
- A more fine-grained study was undertaken of the relationship between the representation of specific Goal II subgoals in the treatment and viewers' subsequent use of particular problem-solving actions or heuristics. The situation here is complex because children's use of specific problem-solving actions or heuristics is a function of at least three factors: (a) the influence of *Square One TV*, (b) what the children would bring to the problem normally, without any influence from *Square One TV*, and (c) the kinds of behavior that would be appropriate to use on the particular problem. As a result, generalizations are difficult to make in this area. However, in many cases, viewers (more than nonviewers) used particular problem-solving techniques that were especially appropriate or powerful in their solutions of certain PSAs.

## DISCUSSION

Great care was taken to ensure that the experimental and control groups were closely matched at the pretest. The only difference in the experimental treatment of the two groups was that the viewing group watched 30 programs of *Square One TV* between the pretest and the posttest, while the nonviewing group did not. As described above, this treatment resulted in the significant improvement among viewers in both (a) the number and variety of problem-solving actions and heuristics used in working on a set of nonroutine problems and (b) the completeness and sophistication of the solutions obtained. Furthermore, the series exerted similar effects on boys and girls and on children of different SES and ethnic backgrounds.

This study has implications in several respects for the current national efforts to improve mathematics education. First, it provides examples of the kinds of problem-solving activities that are feasible at the elementary school level and how they can be incorporated into assessments of problem solving. Second, it illustrates alignment in the sense espoused by the National Council of Teachers of Mathematics: A detailed description of program goals formed the basis of an assessment that measured and interpreted children's behavior. Finally, it shows that sustained unaided viewing of *Square One TV*, a television program built around the use and application of problem-solving processes, can in fact increase problem-solving performance in its target audience.

## REFERENCES

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Peel, Tina, Rockwell, Alex, Esty, Edward, & Gonzer, Kate (1987). *Square One Television: The comprehension and problem-solving study, final report*. New York: Children's Television Workshop.

## APPENDIX 1
## Goals of *Square One TV*

*Square One TV* has three main goals that are further divided into a range of subgoals. The goals (concerning attitudes toward mathematics, the use of problem-solving actions and heuristics, and the presentation of clear mathematical content) guide the creation of material for the series. They reflect an underlying philosophy that is in keeping with that of the current reform movement in mathematics education.

The goals of *Square One TV* are as follows:

GOAL I: To promote positive attitudes toward, and enthusiasm for, mathematics by showing:

- A. Mathematics is a powerful and widely applicable tool useful to solve problems, to illustrate concepts, and to increase efficiency.
- B. Mathematics is beautiful and aesthetically pleasing.
- C. Mathematics can be understood, used, and even invented by non-specialists.

GOAL II. To encourage the use and application of problem-solving processes by modeling:

- A. Problem Formulation
  1. Recognize and state a problem.
  2. Assess the value of solving a problem.
  3. Assess the possibility of solving a problem.
- B. Problem Treatment
  1. Recall information.

2. Estimate or approximate.
3. Measure, gather data, or check resources.
4. Calculate or manipulate (mentally or physically).
5. Consider probabilities.
6. Use trial-and-error or guess-and-check.

C. Problem-Solving Heuristics
1. Represent problem: scale model, drawing, map; picture; diagram, gadget; table, chart; graph; use object, act out.
2. Transform problem: reword, clarify; simplify; find subgoals, subproblems, work backwards.
3. Look for: patterns; missing information; distinctions in kind of information (pertinent or extraneous).
4. Reapproach problem: change point of view, reevaluate assumptions; generate new hypotheses.

D. Problem Follow-Up
1. Discuss reasonableness of results and precision of results.
2. Look for alternative solutions.
3. Look for alternative ways to solve.
4. Look for, or extend to, related problems.

GOAL III. To present sound mathematical content in an interesting, accessible, and meaningful manner by exploring:

A. Numbers and Counting
1. Whole numbers.
2. Numeration: role and meaning of digits in whole numbers (place value); Roman numerals; palindromes; other bases.
3. Rational numbers: interpretations of fractions as numbers, ratios, parts of a whole or of a set.
4. Decimal notation: role and meaning of digits in decimal numeration.
5. Percents: uses; link to decimals and fractions.
6. Negative numbers: uses; relation to subtraction.

B. Arithmetic of Rational Numbers
1. Basic operations: addition, subtraction, division, multiplication, exponentiation; when and how to use operations.
2. Structure: primes, factors, and multiples.
3. Number theory: modular arithmetic (including parity); Diophantine equations; Fibonacci sequence; Pascal's triangle.
4. Approximation: rounding, bounds; approximate calculation; interpolation and extrapolation; estimation.
5. Ratios: use of ratios, rates, and proportions; relation to division; golden section.

C. Measurement
1. Units: systems (English, metric, nonstandard); importance of standard units.
2. Spatial: length, area, volume, perimeter, and surface area.
3. Approximate nature: exact versus approximate, i.e., counting versus measuring; calculation with approximations; margin of error; propagation of error; estimation.

4. Additivity.

D. Numerical Functions and Relations
   1. Relations: order, inequalities, subset relations, additivity, infinite sets.
   2. Functions: linear, quadratic, exponential; rules, patterns.
   3. Equations: solution techniques (e.g., manipulation, guess-and-test); missing addend and factor; relation to construction of numbers.
   4. Formulas: interpretation and evaluation; algebra as generalized arithmetic.

E. Combinatorics and Counting Techniques
   1. Multiplication principle and decomposition.
   2. Pigeonhole principle.
   3. Systematic enumeration of cases.

F. Statistics and Probability
   1. Basic quantification: counting; representation by rational numbers.
   2. Derived measures: average, median, range.
   3. Concepts: independence, correlation; "Law of Averages."
   4. Prediction: relation to probability.
   5. Data processing: collection and analysis.
   6. Data presentation: graphs, charts, tables; construction and interpretation.

G. Geometry
   1. Dimensionality: one, two, three, and four dimensions.
   2. Rigid transformations: transformations in two and three dimensions; rotations, reflections, and translations; symmetry.
   3. Tessellations: covering the plane and bounded regions; kaleidoscopes; role of symmetry; other surfaces.
   4. Maps and models in scale: application of ratios.
   5. Perspective: rudiments of drawing in perspective; representation of three-dimensional objects in two dimensions.
   6. Geometrical objects: recognition; relations among; constructions; patterns.
   7. Topological mappings and properties: invariants.

## APPENDIX 2

This is a description of Problem-Solving Activity C′ (PSA C′), which is used in Children Television Workshop's summative evaluation of *Square One TV*.

The child is told about a person named Dr. Game, who owns a game factory. Dr. Game was recently dismayed to find that his factory had been broken into, and that some of his games had been changed in some way. The child has been hired by Dr. Game to find out what is wrong with one of these games.

The experimenter shows the child the equipment for the game, which consists of the following: two spinners, one numbered 3, 4, and 5 and the other numbered 2 and 6; a coin marked "+" on one side and "×" on the other; a number board with two elasticized loops—one orange and the other green—arranged so that the loops surround two sets of numbers; two stand-up, cut-out players, one of whom wears a sign around its neck saying "Orange" and the other with a sign saying "Green"; and nine plastic chips. The spinners, number board, and players are pictured in Figure 3.

The experimenter explains the rules of the game to the child. To play the game, a spinner-person (not identified further) spins both spinners, getting two numbers, and flips the coin, getting addition or multiplication. Then he or she does the addition or multiplication and finds the answer on the board. If the answer is inside the green loop, then the Green player gets one chip; if the answer is inside the orange loop, then the Orange player gets one chip. Whoever has more chips at the end of nine spins wins the game.

After the child is again told that there is something wrong with the game and that the task is to find what is wrong, the experimenter leaves the child to work alone. A kit of materials (paper, pencils, pens, a calculator, a ruler, a protractor, and some circular stickers) is available for the child to use if he or she wants to.

[What is wrong with the game is that it is unfair to Green. The probability of

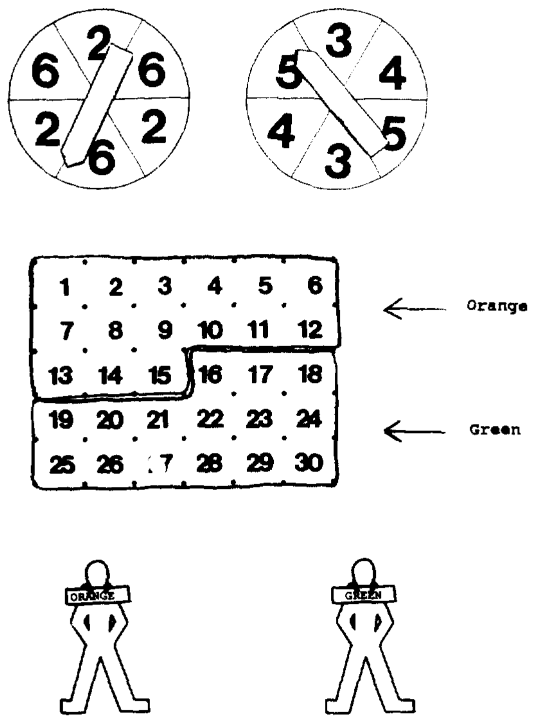


**Figure 3.** Spinners, Number Board, and Players Used in PSA C′

awarding each chip to Orange is ¾, and the probability of Orange's winning more chips than Green by the end of the game is more than .95.]

When the child has told the experimenter what he or she thinks is wrong with the game, the experimenter asks several standardized questions that encourage the child to describe his or her actions, thoughts, and strategies. Then the next task is posed: to fix the game.

[The game can be fixed (or at least made fairer than it is) in a variety of ways: by moving the orange and green loops appropriately; by changing some or all of the numbers on the spinners; by changing the operations on the coin; by awarding more than one chip to Green if the answer is in the green loop; or by some combination of these.]

Again the child is left alone to work on this. The experimenter returns to the table when summoned or if the child seems no longer to be working productively. As before, the experimenter uses a set of carefully structured probe questions to get at what the child was doing and thinking during the period he or she was working on the problem.

**Editor's Note:** This is a synopsis of one part of a study recently conducted by Children's Television Workshop. A full report on the study is currently in preparation, but because of our interest in the study, we have asked the authors to submit this brief report for publication in this issue. We hope to present further details of the study in a future issue of *The Journal of Mathematical Behavior*.

ORIGINAL

# Children's Interest in and Understanding of Science and Technology: A Study of the Effects of CRO

## Executive Summary


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with

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Conducted for Children's Television Workshop, New York, 1995

# *CHILDREN'S INTEREST IN AND UNDERSTANDING OF SCIENCE AND TECHNOLOGY: A STUDY OF THE EFFECTS OF CRO*

## EXECUTIVE SUMMARY

**Conducted for**

**Children's Television Workshop**

**New York, NY**

by

Anne L. Fay

with

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The Executive Summary highlights the major findings from the summative evaluation of the second season of *CRO*. The study had two main purposes. The first was to examine the impact of *CRO* on children's interest in science and technology, with a particular emphasis on the specific topics covered in Season II. The second was to assess children's understanding of the material presented in the series. For further information about the study, please refer to the full report which is published separately.

# EXECUTIVE SUMMARY

In an attempt to contribute to the science education reform effort Children's Television Workshop (CTW) created *CRO*, an animated television series focusing on science and technology and shown on Saturday mornings. *CRO* centers on the adventures of an 11-year-old Cro-Magnon boy, his adopted Neanderthal family and the talking woolly mammoths who are their friends. In the course of their everyday activities, they confront obstacles that serve to motivate the use of a variety of scientific concepts and simple machines. The series aims to introduce six-to 11-year-old children to some basic concepts in science and technology, to stimulate their interest to learn more, and to show them that science and technology is an integral part of everyday life.

## PURPOSE OF THIS EVALUATION

The Learning Research and Development Center was contracted by CTW to conduct and evaluation study of the eight episodes of the Season II of *CRO*. In line with the goals of the series, the three main goals of the study are:

- To assess the show's impact on children's interest in the science and technology topics presented in Season II's shows.
- To examine the show's impact on children's broader interest in science and technology topics and activities that were not presented in Season II's shows.
- To assess the show's impact on children's understanding of the science and technology principles presented in the show.

## DESIGN

On the first two days of the study all children completed baseline measures and several pretest assessments of interest in science and technology. At the beginning of the next session, children were assigned to the *CRO*-group or the *CSD*-group. Children in the *CRO*-group viewed all eight Season II episodes, two shows each week, on non-consecutive days. At the same time, children in the *CSD*-group viewed eight episodes of the Fox cartoon, *Where on Earth Is Carmen Sandiego. Where on Earth Is Carmen Sandiego* was chosen because, like *CRO*, it is an educational, animated series that airs on network television, but its content focuses on geography rather than science and technology. After viewing the second show of each week, children participated in a one-hour activity period, where they could choose among a variety of toys, games, and books that were either related or unrelated to technology. On the day following the activity period children were interviewed in same-sex, same-age pairs. Interviews focused on children's interest in the shows they viewed that week and on their comprehension of the concepts featured in the most recently presented *CRO* episode. Finally, at the end of the four-week treatment period, children completed several posttest measures of interest in science and technology.

### PARTICIPANTS

The sample consisted of 101 inner-city children aged 5 -10, taken from three after-school programs in Pittsburgh (where *CRO* has not been broadcast). There were approximately equal numbers of girls and boys, predominantly minorities and low SES. Within each after-school program children were randomly assigned to either the *CRO*-group or the *CSD*-group.

### MEASURES

We employed a multi-method approach to assess the impact of *CRO* on children's interest and comprehension. There were three types of measures: 1) paper-and-pencil, 2) in-depth interviews, and 3) behavioral observations. These measures included:

- **Baseline:** an assessment of prior knowledge about science and an interest scale to establish children's initial attraction to items that were used in our behavioral measures.

- **Show Appeal:** a paper-and-pencil scale and interview questions that assessed the appeal of each episode.
- **Interest:** paper-and-pencil scales that measured children's interest in science and technology topics and activities before and after treatment, interview questions, and behavioral observations of children as they engaged in various technology-related and non-technology activities.
- **Comprehension:** in-depth interviews that measured children's free recall of the episodes they had viewed, plus sorting and explanation tasks that focused more directly on comprehension of the underlying science and technology concepts presented in four of the Season II *CRO* episodes.

## RESULTS

### *Appeal*

The appeal of all eight episodes of *CRO* was high -- significantly higher than all episodes of *Where on Earth Is Carmen Sandiego*. On the paper-and-pencil ratings between 79% and 92% of the children rated each episode of *CRO* between "Good" and "Great" and in the interviews between 88% and 92% of the children reported liking the episodes. This effect held regardless of age, gender, or science achievement. Reasons for appeal included the inventive problem-solving processes of Cro and his friends as well as more general positive attitudes toward the storylines and characters.

### *Interest*

Several different and complementary measures were used to assess the impact of *CRO* on children's interest in science and technology. This multi-method approach was used to provide a broad and valid picture of the impact of *CRO*. Major findings from the paper-and-pencil interest measures include:

- From pretest to posttest, children in the *CRO*-group (particularly girls), showed a significantly greater increase in interest in watching *CRO* and other science-based television programs (*Bill Nye the Science Guy* and *Beakman's World*) than the *CSD*-group. For both groups interest in non-science shows remained constant from pretest to posttest.
- When asked to rate their interest in doing a variety of activities, the *CRO*-group showed significantly greater pretest-posttest gains than the *CSD*-group in their interest in doing *CRO* -related technology activities (e.g., making a catapult). This effect was strongest for boys. There were no significant changes in children's interest ratings for non-technology activities or technology activities that were unrelated to *CRO*.

These findings were confirmed by interview data:

- Children in the *CRO*-group expressed an interest in acquiring more information about the technology content in *CRO* more often than the *CSD*-group expressed an interest in pursuing the educational content in *Carmen Sandiego*. This effect was statistically significant for six of the eight episodes and marginally significant for a seventh episode. Although children in the *CSD*-group said they wanted to find out more about the show topics, their reasons typically focused on how the topic related to their own personal experiences or prior interests (e.g., interest in an episode on chess because they played chess) rather than acquiring new information.
- On two of the four interviews, significantly more children in the *CRO*-group than the *CSD*-group reported engaging in unprompted activities related to the episodes viewed that week. For example, one girl reported using her mother's compact to see around corners after watching a *CRO* episode on mirrors and periscopes and

other children reported experimenting with floating objects in the bathtub after watching an episode on buoyancy.

Additional support for the impact of *CRO* on children's interest in science and technology comes from their hands-on behavior during four activity periods:

- During the third activity period, children in the *CRO*-group were more likely to engage in activities related to wheels and belts (e.g., build a toy using wheels and belts out of a LEGO kit) after viewing the episode which featured this topic. In addition, only children in the *CRO*-group engaged in an activity concerning timekeepers. The *CSD*-group's choices of *CRO*-related activities showed no such pattern.
- Overall, the *CRO*- and *CSD*- groups were equally likely to engage in *CRO*-related technology activities during the first activity period. However, while the *CRO*-group's engagement in such activities remained stable across the four activity periods, the proportion of *CRO*-related activities that were chosen by the *CSD*-group dropped significantly during the last two activity periods. This finding suggests that the *CRO*-group continued to be interested in the *CRO*-related activities but that the *CSD*-group's interest waned.

### *Comprehension*

Comprehension was assessed via in-depth interviews. One focus of the interviews was on children's recall of the educational and non-educational content of the eight *CRO* and *CSD* episodes. In addition, two comprehension tasks were used; these focused on: 1) children's understanding of the principles underlying the devices in four episodes (Catapults, Heat & Insulation, Timekeepers, and Buoyancy), and 2) their ability to select the devices that would work best for particular purposes (e.g., no tank, an uninsulated tank, or an insulated tank as ways to create a hot shower). Some major findings were: